

NO 41596 000

METAL CONTACTS ON SEMICONDUCTORS(U) UNIVERSITY COLL  
CARDIFF (WALES) R H WILLIAMS 01 APR 88  
DAJA45-84-C-0028

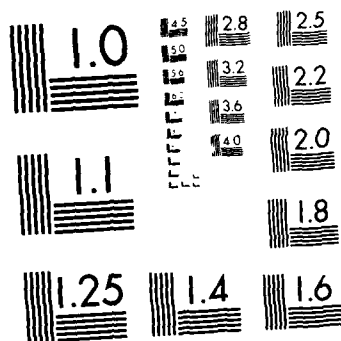
171

UNCLASSIFIED

F/G 7/2

NL





## METAL CONTACTS ON SEMICONDUCTORS

DTIC FILE COPY  
4428-PH-01

②

Principal Investigator: Professor R.H. Williams

Contractor: University College, Cardiff

Contract Number: DAJA 45-84-C-0028

8th Periodic Report: 1st October 1987 - 1st April 1988

AD-A195 680

The research reported in this document has been made possible through the support and sponsorship of the U.S. Government through its U.S. Army Research and Standardization Group (Europe). ~~This report is intended only for the internal management use of the Contract and the U.S. Government.~~

DTIC  
ELECTE  
JUN 07 1988  
S D

**DISTRIBUTION STATEMENT A**  
Approved for public release  
Distribution Unlimited

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By <i>perform 50</i>	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
<i>A1</i>	

28 5 17 049

✓  
Since the last report a number of experiments have been carried out on metal-semiconductor interfaces and semiconductor heterostructures. The range of experimental techniques applied included low energy electron diffraction (LEED), X-ray photoemission spectroscopy (XPS), Raman scattering, and transport measurements, i.e. current-voltage (I-V) and capacitance-voltage (C-V) measurements.

The system investigated most thoroughly within this project is Sb on InP(110). As mentioned in an earlier report this Sb/InP interface exhibits properties which makes it an ideal system to study the formation of Schottky barriers and also test the different theoretical models for this formation. The Raman and transport measurements were performed on both Sb/n-InP and Sb/p-InP. This work has been accepted for publication and preprints are included. *Gordon Duggan & Anthony, 1990* ←

The photoemission studies of this system have been completed by XPS experiments using the ESCALab in Cardiff. Here we concentrated on Sb on p-type InP. Shifts of the indium core level emission lines have been observed due to band bending. Furthermore, the Sb peaks again split as expected from the soft-XPS results obtained on Sb/n-InP in Berlin. This work will be presented at the 19th

International Conference on the Physics of Semiconductors in Warsaw (August 1988).

In addition, a LEED study which was performed in collaboration with Prof. Richter's group in Aachen revealed that the  $1 \times 1$  substrate pattern is still observable at large Sb coverages (approximately 30 monolayers of Sb) indicating strong island formation. This is in excellent agreement with the attenuation curves obtained from substrate core level emission intensities in the SXPS experiment. This full collection of results is now being prepared for publication giving a comprehensive description of the adsorption of Sb on InP(110).

Further progress has also been made studying bismuth on cleaved III-V semiconductor surfaces. Bismuth being very similar to Sb in its structural and electronic properties behaves quite distinct when adsorbed on InP(110). XPS spectra show no splitting of the Bi emission lines as observed for Sb. There is, however, an asymmetry in the lineshape which changes with coverage. The data are being prepared for publication at present.

In the LEED pictures a six fold symmetry structure is superimposed on the  $1 \times 1$  substrate pattern. This structure is likely to correlate with Bi polycrystals, because Bi crystals have trigonal  $A7$  symmetry. Very interesting and unexpected is the fact that

there are differences between the LEED pictures for Bi on InP and Bi on GaAs. On GaAs a splitting of the LEED spots which correspond to the six fold symmetry occurs. This has not been observed for InP. For large coverages of Bi the splitting disappears again for GaAs. On InP we saw streaks instead. This aspect is currently under closer investigation and further LEED experiments are being carried out at various substrate temperatures on both substrate materials. Differences have also been found in the attenuation of the TO substrate phonon derived from the Raman spectra and the intensity of elastic scattered light (Rayleigh intensity) depending upon the substrates (InP or GaAs) used.

The development of the Schottky barrier at the interface is also being studied using electric field induced Raman scattering (EFIRS) which measures the electric field associated with the band bending in the semiconductor via the symmetry forbidden LO phonon scattering. Results have already been obtained for Bi on p-InP and Bi on p-GaAs. Variations of the band bending have been found similar to the Sb/III-V systems. The barrier heights at large Bi coverages agree very well with those evaluated from I-V measurements. It is intended to continue the investigations of the Bi/III-V systems to obtain a similar detailed picture as for the Sb/III-V systems. The final goal is to gain an in-depth

understanding of the physical mechanisms that determine the difference between Bi and Sb on III-V semiconductors. Strain built up as the overlayer grows and crystallizes may be considered as one important factor that contributes to the observed differences.

Besides the work on metal-semiconductor interfaces a programme on InSb/CdTe heterostructures has made substantial progress. This combination of the large band gap semiconductor CdTe with the small band gap semiconductor InSb is lattice matched and extremely suitable for applications in ultra fast transistors as well as infra red lasers and detectors. There are, however, problems to grow these heterostructures with abrupt interfaces.

Raman experiments have been carried out on CdTe layers deposited onto InSb(100) surfaces at various substrate temperatures. New samples were supplied by T.D.Golding (U.S.Army Center for Night Vision and Electro-Optics). The Raman spectra taken of these samples confirmed the results obtained earlier from samples grown by K.J.Mackey (R.S.R.E. Malvern) /1,2/. A  $\text{In}_2\text{Te}_3$  layer liberated Sb have been found at the interface when CdTe had been deposited at high temperatures (600K). However, the quality of the InSb(100) layer of the new samples was better because an InSb buffer layer of superb quality was grown before depositing CdTe. The Raman

spectra thus reveal very nicely how the degree of substrate disorder increased with increasing substrate temperature. Since the formation of  $\text{In}_2\text{Te}_3$  is likely to be due to a Cd deficiency, more samples were grown under a Cd overpressure. They are currently under investigation. The programme is also being expanded to study InSb/CdTe superlattices. Revealing information about the chemical phases, interfacial disorder, and probably layer thicknesses via folded phonon modes Raman spectroscopy is an extremely powerful tool to investigate these multilayer structures.

#### References

- /1/ D.R.T.Zahn, K.J.Mackey, R.H.Williams, H.Munder, J.Geurts, and W.Richter, Appl.Phys.Lett., 50, 742 (1987): The Formation of Interfacial Layers in InSb-CdTe Heterostructures Studied by Raman Scattering.
- /2/ K.J.Mackey, D.R.T.Zahn, P.M.G.Allen, R.H.Williams, W.Richter, R.S.Williams, J.Vac.Sci.Technol. B5, 1233 (1987): InSb-CdTe Interfaces: A Combined Study by Soft X-ray Photoemission, Low Energy Electron Diffraction, and Raman Spectroscopy.



END

DATED

FILM

8-88  
STIC